Gains from an Integrated Market for Tradable Renewable Energy Credits (TRECs)[1]

PALLAB MOZUMDER [2] ACHLA MARATHE [3]

Abstract

Decoupling the environmental attributes of renewable energy (RE) generation from the physical unit of energy is an innovative mechanism for marketing green or renewable power. The introduction of 'Tradable Renewable Energy Credits' (TRECs) allows the green power attributes to be sold or traded separately from the physical unit of energy. Since the green power certificate system removes potential locational and physical bottlenecks, both suppliers and consumers gain flexibility in the marketplace. The TREC is also an efficient tool to meet 'Renewable Portfolio Standard' (RPS) required by different states in the U.S. This paper focuses on the state wise RPS requirements and discusses the implications of an integrated TREC market. It offers a competitive setting to consumers to pay for renewable energy and a cost effective tool to thrive renewable energy generation, Grace and Wiser (2002). This paper also highlights some practical difficulties that should be addressed in order to establish an efficient integrated TREC market.

Key Words: Renewable Energy (RE), Tradable Renewable Energy Credit (TREC), Renewable Portfolio Standard (RPS).

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[1]The authors would like to gratefully acknowledge the comments and suggestions by the editor and three anonymous referees.

[2]1915, Roma NE, Dept. of Economics, University of New Mexico, NM-87131. Los Alamos NM 87545. Email: `pallab@unm.edu`. The work was done while the author was a summer intern at the Los Alamos National Laboratory.

[3]Contact author, Los Alamos National Laboratory, Computer and Computational Science (CCS-3), MS B265, Los Alamos NM 87545. Email: `achla@lanl.gov`.

1 Background

Deregulating the energy sector and achieving the environmental goals through reducing green house gases (GHG) are the two dominant trends in the contemporary U.S. energy policy. The deregulation in energy sector allows the consumers to buy power from the provider of their choice. In order to achieve environmental targets in a liberalized or deregulated market (DOE, 1991 Public law, 1992), the design and implementation of policy measures and incentive schemes must be compatible with this open market framework. The incentive schemes that have been established in the pre-liberalization phase may not be suitable for the liberalized market (Jensen and Skytte 2002). On the basis of cost effectiveness, economists have been advocating for market-based environmental regulations to meet the environmental targets (such mechanisms first discussed by Crocker 1966, Dales 1968 etc.). As a market-based tool, tradable renewable energy credit (TREC)[4] has gained extensive interest in Australia, Europe and elsewhere to meet the environmental targets of renewable energy generation in past few years. In U.S. too, the idea of TREC is gaining popularity. A number of states (e.g. Arizona, Nevada, Texas, and Wisconsin etc.) allow for or require TRECs to meet renewable portfolio standard (See Berry 2002 for more details). This paper discusses the scope and implications of integrating TREC market based on the RPS requirement across different states in the U.S. It analyzes the potential gain in welfare, the practical barriers and various risks associated with this type of market.

TRECs provide more than just a cost efficient renewable energy system. TRECs spur competitive technology to generate renewable energy, create impetuous to establish wider spectrum of cost effective technologies that bring further economic benefits to the country. In U.S., in 1996 the photovoltaic industry generated more than $800 millions in revenues and 15000 high quality jobs (manufacturing, engineering, sales, installation, servic-

[4] Sometimes also mentioned as 'certificate' instead of 'credit'. In this paper no distinction is made between the two.

ing, maintenance etc.) in 800 companies. Biomass based energy generation has created more than 66000 jobs nation wide, $1.8 billion in personal and corporate income, more than $460 million in federal and state taxes. Each year the geothermal industry contributes about $40 million to U.S. treasury (NREL 1999). If the TREC system is mandated through the RPS it will widen these economic benefits to a large extent.

Integrating the TREC market also has implications on the climate change plan that was offered as an alternative to the Kyoto protocol by the U.S. The climate change plan calls for voluntary measures to reduce the rate of emission and is in sharp contrast to the Kyoto protocol which sets mandatory emission targets. President Bush's voluntary climate change plan sets the target of reducing "greenhouse gas intensity" by 18% in next 10 years. The proposed integrated TREC market can be used to realize this target in the same fashion the EU countries use the green certificates to meet the Kyoto protocol.[5] The alternative climate change plan states that it will respond to broad market based program if the US is not on track by 2010 to meet the targeted goal (Platts Global Energy 2002). We believe it will be wise to set up the broad market based programs (e.g., integrated TREC market) at present rather than wait till 2010.

The remainder of this paper is organized as follows. Section 2 discusses the basic features of a TREC market. Section 3 describes the Australian, European and U.S. experience with TREC market. Section 4 discusses various issues related to integrated TREC market such as the scope of integration, gains from trade, practical difficulties in integrating markets across states, state specific RPS regulations etc. The final section provides discussion and conclusions.

[5]Common EU emission reduction policies and individual GHG reduction targets set by the member countries are in the process of being implemented to meet the Kyoto requirements (Morthorst 2003). Policy makers are considering a tradable CO_2 permit market to achieve CO_2 emission reduction within the power industry and other energy intensive industries. Morthorst (2003) analyzes competing institutions to see which one is efficient in a situation where other emission permit markets coexist with TREC market. He views that a combination of international tradable permit market for CO_2 and an international TREC market will be efficient in achieving national CO_2 reduction targets if the two markets are well coordinated.

2 The TREC Market and its Basic Features

TRECs have been suggested as a market based instrument to reduce the emission of the green house gases caused by the power generators.[6] TRECs are used to represent the "greenness" of a unit of renewable energy. The advantage of TREC is that it allows the generated unit of electricity to be divided into two parts: the physical electricity and the associated greenness. By separating the environmental attributes of renewable energy generation from the physical unit of electricity, TREC allows the green power attributes to be sold or traded separately from the physical unit of energy (Mitchel and Anderson 2000). Since the TREC system removes locational and physical bottlenecks, both suppliers and consumers gain flexibility in the marketplace. Consumers need not switch to an alternative energy generator to purchase renewable power and customers of the regulated utilities gain the ability to purchase renewable power where none may be offered by the host utility or where utility offerings are considered inferior to the renewable energy (RE) certified product.

Literally TREC is a document through which it is claimed that a unit of electricity has been produced from a renewable energy (RE) source. Generators receive a certificate for each predefined unit of electricity produced from their RE scheme. Allowing TREC would make a unit of energy generated from renewable and non-renewable source indistinguishable. If TRECs are allowed to meet RE obligation (e.g. RPS required by several states), renewable energy generators will be able to earn revenue not only from selling the power but also from selling the additional certificates (TRECs). Figure 1 explains this in further detail.

Trading the environmental attributes separate from the units of energy helps to avoid

[6]U.S. electric utilities are responsible for 26% of the nation's nitrogen oxide and 64% of the sulfur dioxide emissions. It ranks first among U.S. industries emitting toxics as listed in the federal Toxic release inventory and emits more than the paper, chemical, plastics and refining industries combined (www.ucsusa.org).

underlying complexity of energy trading. First of all, establishing separate transmission network to supply renewable energy distinguishable from traditional fossil fuel based energy would be very expensive. Secondly, in states where there are no green marketers, opportunities for bundled sale of energy and environmental attributes would be limited. Also, most of the energy markets are multi-scale in time. The forward markets (e.g. day-ahead, hour-ahead, long term) are settled ahead of time whereas the spot market is settled in real time. Decoupling of environmental attributes allow the REC transaction to carry on its own schedule. If the environmental attributes and energy remained bundled, the regulator would have to deal with the delivery time and other, often complex issues in the energy trade. It would also reduce the uniform commodity nature of the energy trading unit and make it harder to evaluate in the real time whether the energy source is renewable or not (Rackstrow and Palmisano, 2002). In bilateral transactions and where all generators are forced to sell into spot markets, decoupling of environmental attributes is essential to obtain the green premium.

Figure 1 compares the bundled (a) and unbundled (b) transaction of energy and its environmental attributes. Panel (a) shows a trading structure where a renewable energy plant sells the energy and its environmental attributes as a single commodity. In this case, if the consumer wants renewable energy, its host utility has to be a renewable energy producer. The trading structure of Panel (b) allows the renewable unit of energy to be split into two components: a base energy unit and a REC unit which represents the environmental attributes of the renewable energy. The renewable energy producer can sell the base energy and REC to different suppliers. In Panel (b), the producer of renewable energy sells base energy to supplier A and REC to supplier B. This arrangement offers consumers the option of buying base energy from any supplier they choose and yet contribute in the production of renewable energy by buying REC. This might occur when a consumer wants to buy renewable energy but its host utility does not have any renewable energy plant and the consumer does not want to switch from the host utility. In our example, consumer 1 buys base energy from supplier A and REC from supplier B while consumer 2 buys only REC from supplier B and his base energy from a different host utility.

TRECs also provide flexibility to the generators when they are mandated to produce a certain share of electricity from renewable sources. The cost of generating renewable energy may substantially vary across generators due to their location, limited supply of renewable inputs and the existing technology. The trading of RECs allow the non-renewable generators to buy the certificates from a renewable generator to meet the requirement in a cost effective way. We discuss this topic in more detail in section 4. Extending the trade of RECs across states would further enhance the flexibility to both consumers and producers. This also results in higher economic efficiency to the society as a whole.

Figure 1 to go about here.

3 Experience with TREC Market in Australia, Europe and U.S.

Australia was the first country to create a national renewable energy market using tradable certificates. The purchasers of wholesale electricity are required to ensure that a percentage of the electricity bought is from the renewable sources (Andrews 2001). This has been achieved through the creation of a TREC market. In Europe, several countries are supporting TREC trading, not only to ensure compliance with greenhouse gas reduction targets or renewable energy obligations, but to serve voluntary demand for green power as well. In Netherlands, a voluntary REC market has existed since 1998. Danish market followed the footsteps of the Dutch market although the Danish model is not exactly the same as the Dutch.[7] Certificates traded in a separate and purely financial market are used to cover an

[7]The Dutch system is voluntary whereas the Danish system is obligatory for all consumers to buy a certain share of electricity generated by the renewable sources, see Bird et al. 2002. However, note that the Danish

obligatory share in the Danish market. All renewable energy technologies are certified for producing green or renewable electricity and issued a REC per unit of production, which can be sold to distribution companies or other electricity consumers with the obligation to buy renewable electricity.

Some states in the U.S. use the Renewable Portfolio Standard (RPS), a mechanism that requires utilities to maintain (in some cases gradually increase) a portion of electricity produced from renewable resources. The Renewable Portfolio Standard (RPS) is a flexible, market-driven policy that can ensure the environmental benefits of wind, solar, biomass, and geothermal energy production (Beck et al. 2002). The RPS requires all electricity generators (or electricity retailers, depending on policy design) to demonstrate, through ownership of credits, that they have supported an amount of renewable energy generation equivalent to some percentage of their total annual kWh sales. For example, if the RPS is set at 5%, and a generator sells 100,000 kWhs in a given year, it would need to possess 5,000 credits at the end of that year. In order to maintain RPS without owning any renewable generators, TRECs' existence is critical. The RPS relies almost entirely on the private market for its implementation. Such regulation implemented through market will result in competition, efficiency, innovation and will deliver renewable energy at a significantly lower price. See Morthorst (2000, 2001), Neilson and Jeppesen (2000, 2003).

Tradable Renewable Energy Credits (TRECs) play a critical role in meeting the RPS requirement. At present Texas, Arizona, Wisconsin and Nevada allow for or require the use of TRECs while some other states are in the process of introducing TRECs (for more details see Berry 2002). A credit is a tradable certificate of proof that one kWh of electricity has been generated by a renewable-fueled resource. Credits are denominated in kilowatt-hours (kWh) and are a separate commodity from the power itself. Although the U.S. government is just beginning to recognize the TRECs' potential, several companies and organizations

model is yet to be fully implemented.

have started to offer TREC on experimental basis. PG&E's National Energy Group is selling TREC from their New York wind farm throughout the northwest region.[8] The Los Angles Department of Water and Power is also selling TREC to the interested parties.[9] Given that most RPS requirements are mandatory rather than voluntary, our discussion will mainly focus on implications from a mandatory RPS requirement in an integrated TREC market.

4 Issues Related to Integrated TREC Market

4.1 Trade Across States using Integrated TREC Market

Given that the TREC market is getting more prominence in the U.S. for renewable energy generation, this study advocates an integrated market for TREC that will allow the credits to be traded across the states. This will help meet the RPS standard maintained by different states in a very cost effective manner. Table 1 summarizes the status of REC trading in different states in the U.S. The first two columns show the states that officially allow REC trading to meet mandated RPS requirement (inside the state). The third column shows whether a detailed program has been designed to operate REC trading. The last column shows that three out of ten states recognize the out-of-state resources to meet the RPS standard requirements.

Table 1 to go about here.

When only in-state renewable resources are allowed for RPS compliance, the price of tradable credits is determined in a straightforward fashion through market interactions of the in-state actors. In an integrated market, the price of tradable credits will be determined through the market interactions of the in-state as well as the out-of-state actors. If such an

[8]www.purewind.net
[9]www.ladwp.com.home/htp

integrated market works without any imperfection, the link between the price of electricity and price of the certificates will be the following:

$$MC_c = MC_r - P_e$$

where MC_c is the marginal cost of certificate, MC_r is the marginal cost of producing energy from renewable source and P_e is the market price of energy. That is, the price per unit of renewable energy will be the market-based price for physical power and the price of the tradable green certificate. Competition across the state in the certificate market ensures that the supply price for green certificates reflects the actual price differential between renewable and non renewable power and the price of the certificates will be equal to the MC of producing certificates. The marginal cost (MC) of producing the certificates varies across states due to the differences in the availability of renewable inputs (e.g. wind, solar, geothermal, hydro). A state with a shortage of renewable resources (i.e. higher MC of producing certificates) can buy certificates from a state with the surplus of renewable resources (where MC of producing certificates is lower). In this case, the state with shortage of renewable resources faces a supply constraint (not able to supply enough credit required to meet the RPS) and the state with abundance of renewable resources faces a demand constraint (not enough demand to sell additional credits after meeting the RPS). This is shown in Panel (a) and (b) of Figure 2. Panel (a) shows that state A is facing a demand constraint which results in a local price of P_D^A and quantity Q_D^A. Similarly, Panel (b) shows that state B is facing a supply constraint. The price in state B is P_D^B and quantity Q_D^B. State A has lot of excess capacity whereas state B has excess demand of REC. Panel (c) shows the aggregated demand and supply curves. If trade of RECs is allowed across states, the clearing price and quantity would be P_T and Q_T^{A+B} respectively. State A would export the surplus RECs raising its domestic price and state B would import the RECs to overcome the supply constraint which lowers the price to P_T. In this example both state A and B gain from the trade and are able to meet their RPS requirement. The society as a whole becomes more efficient in providing renewable energy by extending the TREC market beyond the state boundaries.

Figure 2 to go about here.

Figure 3 shows the gains from trade in a slightly different way. It shows that if two states have different cost structures for producing renewable energy, both can benefit by trading the RECs. In state A, the marginal cost of producing TREC is initially high but goes down gradually. This could be due to high initial fixed costs for renewable energy generators. On the other hand in state B, the marginal cost of producing TREC is initially low but rises at higher levels of production. This could occur due to shortage of renewable resources in state B. From Figure 3 it is easy to see that if the total TREC requirement in state A and state B is less than Q_e, e.g. Q_l, it would be cheaper for state B to produce all of Q_l and sell part of it to state A. The marginal cost of production in state A (MC_l^A) is higher than the marginal cost of production in state B (MC_l^B). Similarly, if the total TREC requirement in higher than Q_e, e.g. Q_h, it would be cheaper for state A to produce all of Q_h and sell part of it to state B. The marginal cost of production in state B (MC_h^B) is higher than the marginal cost of production in state A (MC_h^A). However, if the total TREC required is Q_e, both states would be equally efficient in meeting the requirement.

Figure 3 to go about here.

4.2 Scope of Integration and Gains from Trade

In the previous subsection we discussed different hypothetical situations to demonstrate the gains from trade. Someone might argue that this is not a true representation of the availability of renewable resources in different states of the U.S. To investigate this we look into the price premiums offered by different renewable energy certificate marketers. As Table 2 shows, the price premiums vary from 1.6 cent/kWh to 4 cent/kWh. The lowest price premium (1.6 cents) is in California and highest price premium (4 cents) is in New York.[10] This difference in premium is not surprising given that California has plenty of wind and water resources to produce renewable energy whereas New York has only limited renewable resources.[11] To meet the RPS (assume that New York and California has some RPS requirement) both New York and California can gain from trading the TREC with each other. Note that the RPS requirement does not have to be the same in two states. The difference in price premiums may appear negligible but note that this difference is per kWh and both these states use millions of kWh of energy. The difference in price premiums could occur due to several other reasons e.g. differences in demand for renewable energy, differences in sophistication and market knowledge of the buyers in voluntary programs, differences in cost of conventional energy supply, differences in utility pricing methods, differences in costs of various renewable energy technologies and differences in quality of renewable energy from place to place.[12] Future research can disaggregate factors that influence the price differences. Table 2 shows that the price premiums offered by the green certificate marketers vary significantly depending upon the location and type of renewable resource used. This indicates the potential for integration of the TREC markets across different states.

The empirical analysis of these differences across states is lacking because of the data availability. Most states have either just implemented or started to consider implementing RPS.[13] However different findings indicate that the cost of renewable technologies varies considerably within and across the states.[14] On average the U.S. wind generators get 10%

[10]The variation in price premiums is getting wider as more and more companies offer renewable power in different states (for details see Swezey and Bird 2000).

[11]In 2001, New York had 4577 MW of renewable energy generating capacity, of which 4443 MW was hydro capacity.

[12]The authors would like to thank an anonymous referee for pointing this out.

[13]The first implementation of RPS was in year 2000 and most of the other programs started between 2001 and 2003 (GDS 2000).

[14]For instance, in Hawaii generating electricity from biomass ranges from 19-25 cents/kWh, whereas for wind it varies from 8-11 cents/kWh (GDS 2000). In the California-Southern Nevada region, the least cost

advantage over natural gas fueled generators. The cost of generating renewable energy from biomass is about two times more than wind and gas combustion turbines. The oil fired turbines are two-three times more expensive than natural gas fired ones. In the Northwest and Southwest regions, the cost of renewable energy generation is almost the same as California except for biomass. The cost of generating renewable energy from biomass is one-fourth less expensive in Southwest and Northwest than in California (GDS 2000).

There is also substantial differences in the cost of conventional energy supply. An earlier analysis showed that the average electricity prices ranged from 3.7 cents/kWh in Washington state to 10.8 cents/kWh in New York and New Hampshire (Ando and Palmer 1998). Electricity prices are higher in states that are dependent on nuclear and oil-fueled plants (northeast states and in California, Alaska and Hawaii) compared to northwest states that have relatively cheap hydropower. In addition different states have different utility pricing system. The price differences of certificates across states may be influenced by these factors. Sophistication of the market set by regulatory authority, differences in demand for renewable energy and the information available to the buyers and sellers of the certificates may also influence the price of the certificates.

An integrated TREC market can be rationalized even if the difference in price premiums is caused by factors other than demand and supply of renewable energy.[15] This is because integration will provide greater economies of scale in implementing RPS regulation.[16] Integrated TREC system will reduce the price fluctuations of the certificates and will resolve some of the institutional differences mentioned before.

Table 2 to go about here.

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renewable technology is geothermal but the available capacity is limited.

[15]Please refer to the factors given at the beginning of this section.

[16]For instance Nevada's 1% RPS requirement is too small to establish a single state TREC system.

4.3 How would the integrated TREC market work?

To effectively set up an integrated TREC market, an obligation or minimum requirement of RE has to be imposed at some point of power supply chain (production, transmission, distribution or consumption). RPS is one way of imposing this obligation. Some states have already agreed to maintain the RPS while others are in the planning stages. In UK the obligation has been placed on the suppliers while in Denmark it has been imposed on the consumers. In the U.S., in most cases, it is on the generators and distributors (Bird et al. 2002). Usually government is responsible for certifying credits, monitoring compliance and imposing penalties if necessary. For generators that are not in full compliance with the RPS, the administrative agency would assess an automatic penalty for each credit that the generator failed to produce based on the requirement. The amount of the penalty should be several times the cost of actual credit. A high penalty level makes the policy self-enforcing by avoiding the need to resort to costly administrative and enforcement measures. For instance, after the federal SO_2 allowance trading program, an automatic $2,000/ton penalty (indexed to inflation) was imposed for each excess ton of SO_2 produced. Because of the high penalty associated with noncompliance, the EPA has not been required to take any enforcement actions. It has been far more economic for power plants to comply than to not comply.

The regulation set by the government or its agency specifies the details on how to comply, including: the type of renewable resources to use, time duration for validity of credits and other related contractual terms of agreement. Generators and utilities decide for themselves whether to invest in renewable energy projects and generate their own credits or enter into long-term/short-term contracts to purchase the credits. Only the bottom line is enforced: possession of a certain number of credits at the end of each year. This way the credit system provides compliance flexibility and avoids the need to "track electrons".[17]

[17] If the restriction is imposed on the consumers, all consumers of electricity across the states are obligated

The market for TREC will function solely as a financial market; the only relation to the physical electricity market will be given by the upper limit of certificates, which cannot exceed the amount of electricity produced by the renewable technologies. The demand for the TREC is given by distribution companies or other consumers whereas the supply is determined by the electricity generation from renewable technologies. Setting up the RPS standard is also a crucial thing to consider. The main objective of RPS is to foster development of renewable capacities. The RPS standard substantially affects the integrated TREC market. If the standard is too low, the realized price of TRECs might be too low to secure development of new capacity. On the other hand, if the standard is too high then the energy generators/consumers would have to pay a high price (penalty payment) for not fulfilling the standard. In that case, the trading of TREC across the states will draw the TRECs from low standard state to high standard state as well as from low price state to high price state as shown in our model. The penalty price for non-compliance must be kept higher than the market price of TREC to provide incentive for developing new renewable capacities.

4.4 RPS Regulations Across Different U.S. States

Each of the states in U.S. that adopted RPS legislation has some unique features. These features in most cases reflect state's specific energy supply situation and the types of renewable resources that are technically feasible (GDS 2000). The size of the RPS also varies widely across the states, for instance the RPS requirement is 1% in Nevada and 30% in Maine. Wiser (2000) provides an excellent comparative review of RPS across different states. In

to buy a certain share of electricity generated by renewable technologies. The major part of this consumer demand will be covered by the distribution companies, which will buy the electricity on behalf of their consumers. Large energy buyers and other consumers who do not buy energy from the distribution utilities (produce their own energy or trade directly with the energy generators) will have to cover an equivalent share of their consumption with renewable energy. Per unit of electricity produced from renewable sources (per MWh) will get a credit (TREC), which can be sold to distribution companies, electricity generators, consumers who are obligated to produce or use certain fraction of renewable energy.

Maine, the RPS was enacted with the opening of retail electricity market in March 2000. There the renewable technology includes fuel cells, tidal power, solar, wind, geothermal, hydro, biomass and municipal solid waste (under 100 MW), and high efficiency cogeneration systems of unlimited size. The RPS requirement was only 30% of sales in 2000 although the share of renewable energy generation was 46-51% of total energy. The RPS compliance cost in Maine is fairly low (0.1-0.15 cents/kWh premium over conventional resources).[18]

Texas is the first state to introduce credit-trading program which is administered by the ERCOT ISO (independent system operator). The renewable technology includes solar, wind, geothermal, hydro, wave, tidal, biomass, biomass-based waste products and landfill gas. The draft regulations require 2000 MW new renewables by 2009. The facilities installed after 1995 are eligible for credit for producing above the 2000 MW requirement. The retailers who do not have required amount of RECs are levied a penalty of $50 MWh or 200% of the cost of RECs.

In Iowa the "Alternate Energy Production Law 1983" was revised in 1991 to include solar, wind, methane recovery and biomass as renewable technologies. The law required investor-owned utilities (IOUs) to have 2% of 1999 sales from renewable resources. In 2000, the Arizona Corporation Commission approved the "Solar and Environmentally Friendly Portfolio Standard", which allowed only the solar PV and solar thermal electric technology to meet the standard. The requirement was 0.4% of distributed electricity by first January 2001 and 1.1% from solar by 2007. In Massachusetts solar, wind, clean biomass are considered renewable but hydro and municipal solid waste (MSW) are not. The Massachusetts Division of Energy Resources (DOER) is moving ahead to implement RPS and considering not only to set up a penalty for non compliance but also require the non compliant trader to make up for the short fall in future years.

[18]The current set-up in Maine does not provide much incentive to increase renewable generation, it may actually lead to a drop in renewable energy production. See Porter and Wiser (2000).

In New Jersey, credit trading is jointly implemented by NJ Board of Public Utilities and NJ Department of Environmental Protection. The RPS is comprised of two tiers: Class I technology includes solar, wind, fuel cells, geothermal, wave, tidal energy, landfill gas, sustainable biomass and class II includes municipal solid waste (MSW), hydro that meets high environmental standards. The RPS requires 25% of new units to be renewable.

Wisconsin is the first state to adopt RPS without opening its market to competition. The renewable technology in Wisconsin includes wind, solar, biomass, geothermal, tidal, a fuel cell that uses a renewable fuel, hydro under 60 MW. The present requirements is 0.5% but increases to 2.2% by 2011.

In Connecticut the supplies are allowed to satisfy the RPS standard through credit trading. The Connecticut legislation divides the renewable technologies into two classes: class I technologies include solar, wind, hydro, sustainable biomass, landfill gas, fuel cells and class II technologies include hydro, MSW (municipal solid waste), other biomass. The Connecticut Department of Public Utility Commission (DPUC) enacted regulation that RPS be based on energy rather than capacity though it was changed back to energy standard in the same year 1999.

In Nevada 50% of renewable energy comes from solar and the rest 50% come from wind, biomass, geothermal in state. The present requirements are 0.2% in 2001 which increases by 0.2% biannually and goes up to 1% by 2009. Although Nevada is one of the first states to approve RPS policy, it is yet to fully implement RPS. In Pennsylvania, energy from the hydro sources is considered non-renewable. The RPS policy is imposed on a utility-by-utility basis and differs for each utility service territory. The above discussion shows that there is a wide variation in the RPS standard across states both in terms of requirements and regulations.[19] Hence, the main obstacle in setting up an integrated TREC market is the

[19]For instance, Massachusetts does not recognize hydro and municipal solid waste as the renewable resources whereas they are recognized in some other states. In Maine, the RPS requirement took effect when the retail electricity market opened in March 2000. On the other hand, Wisconsin adopted the RPS regulation

incompatibility of regulations. The accounting, verification and credibility issues are likely to be resolved through the federal regulatory intervention (e.g. Environmental Protection Agency, Federal Energy Regulatory Commission etc.).

4.5 Drawbacks, Barriers and Associated Risks with Integrated TREC Market

Setting up an integrated TREC market to allow trade across the states has some practical difficulties. A number of key issues need to be agreed upon by all the participating states. The states do not necessarily require to set equal RPS standard but they need to set a unique standard to claim the credits for renewable energy.[20] A similar situation arises in integrating such a market among EU countries. This is partly because the standard of certification schemes of different countries is not necessarily compatible with each other. To address this problem, in Europe, there is an effort under way to create a common platform for certificate trading at the continental level. The generation information system being developed in New England may fulfill a similar function for the six New England states, but it is not clear whether different regional systems in the US will be compatible (see Figueiredo 2001 for more details). As in Europe, there will eventually be a need to harmonize such verification systems. Setting up an integrated TREC market is under way in EU countries (Skytte 2000), although due to lack of direct federal control, the EU situation is much more complex than the U.S. The lessons learnt from the European experience can be very helpful in setting up an integrated TREC market in the U.S. In Europe specific concerns include that TRECs from one country might undermine the development of renewable energy in the purchasing country, and that subsidized renewable energy in one country could compete

without opening its market to competition. For non compliance also, the kind of penalty varies across states. For example, most of the states just charge a fine for non compliance, instead in Massachusetts, in addition to paying a fine, the shortfall needs to be made up in future.

[20]For example what will be the definition of renewable energy (e.g. will large hydro be included or not) or what will be the time length for validity of the credits etc. See Golove et al. 2000 for differences in the definition of renewable energy set by different states.

unfairly against the unsubsidized renewable energy from another country. These concerns will also have to be addressed in the U.S.

Due to the direct link between the energy prices and TREC prices, the price fluctuation at the energy market will certainly influence the certificate price. Given the marginal cost of production, a low market price for a unit of energy will correspond to a high marginal cost of certificates and vice versa. In addition, the variability in the supply of renewable resources (for instance due to seasonal variation in wind and solar power) may cause instability in the TREC market. It is important that the TREC market is designed in such a way that substantial price variations can be handled. Extending the TREC market beyond states can reduce these fluctuations substantially. The interplay between markets will dampen the price fluctuation of renewable energy and result in a more stable flow of revenue to the investors. See Grace and Wiser (2003), Lemming (2003) and Berry (2002).

Unbundling the physical unit of energy from the environmental units in an integrated TREC market causes the out of state/region buyers to pay for the environmentally friendly generation without actually receiving any local environmental benefits.[21] Ingenious ways of market integration can resolve this problem to some extent. (See Midttun and Koefoed (2003), Grace and Wiser (2002)). Section 5 discusses these options in more detail. Providing more environmental knowledge to the people and highlighting the global nature of environmental hazards created by the green house gases may also reduce the local concern.

4.6 Extent of Banking and Borrowing

The intermittent nature of renewable energy generation can lead to high volatility in the TREC market. Lemming (2003) discusses two critical risk factors that influence the financial risk for investors of renewable energy. One is fluctuation in production and the other is imperfect information about supply and demand. Lemming (2003) argues that fluctu-

[21] Sometimes it is hard for the consumers to accept the system of buying credits that represent the green attributes of energy produced in another state while their own state is still producing energy from fossil fuel.

ations in the renewable input tend to decrease the short run financial risks involved with investment in renewable energy due to the negative correlation between the volumes of renewable energy generation and the TREC price. The second type of risk arises from the unpredictability of the supply and demand of the TRECs. The demand side information is related to future policy uncertainty whereas the supply side is linked with the intermittent nature of the renewable energy generation. The lack of supply and demand information will cause investors to demand a higher risk premium. Lemming (2003) argues that regulator can minimize this effect by being transparent and disseminating future policy and other related information. Berry (2002) also discusses these issues in detail.

The volatility in the TREC market can also be reduced if banking and borrowing of TRECs is allowed. One major question however is how long the allowed time period should be for banking. There are different opinions at this point. For instance, the *Green-e Program* requires "true-up" period of one year and three months for matching renewable energy generation with its sales (see Green-e 2001). The Center for Resource Solutions (CRS 2001) argues that the highest economic value for TRECs will be derived if owners have the option to hold and resell TRECs anytime during a three-year period following its creation. Extensive banking period is likely to redeem the expansion of renewable energy generation and may also create higher transaction cost as it will complicate legal arrangements and enforcement against consumer deception. The desire to bank certificates is expected to be lowered as the TREC price falls with more renewable technology in place.

4.7 Institutional Reasons for Lack of Interregional Trades

Compatibility of regulation is a major component of an integrated TREC market. In establishing an integrated market for TREC, the European Union is facing a significant challenge in terms of synchronizing and integrating multiple policy set-up from different national regulatory background and resource endowments (Midttun and Koefoed (2003)). In European context, Meyer (2003) argues that a precondition for an integrated market is to have consistent national rules that at least preclude unfavorable competition. EU has set up a pilot project to obtain practical experience on international trade of green certificates on a limited scale (RECS 1999).[22] Under this project certificates will be traded between countries and at least one third of the transaction of certificates by the utilities will need to be international. Under the umbrella of federal regulatory framework U.S. can also design such an experimental project at an interregional level.

Nielson and Jeppesen (2003) focus on a few crucial points that need to be addressed to establish an integrated TREC system. First, what technologies and fuel resource should be considered eligible for certificates. One state's exclusion of certain technology imposes a trade restriction on another state's certificate generated by that technology. For example, wind is considered as a renewable source in Texas but not in Arizona. Second is harmonizing market stabilization mechanism. Different states may have different ceilings and floors to stabilize the price of certificates. States need to agree on a single price restriction. The same rule applies for determining the penalty for non-compliance. Otherwise the highest minimum and the lowest maximum price restriction will dominate in the integrated system. The validity of the certificates also needs to be harmonized across states. Allowing trade between one-year valid certificates and five-year valid certificates is unfair. The difference in the banking and borrowing rules also restrict trade in the same fashion. Third, state regulations to stimulate or support currently uncompetitive renewable technologies may distort the competition and hence should be standardized. Finally, trading of certificates that were generated through voluntary versus mandatory requirement should not be allowed. In one case the non-complier faces penalty while in other case he does not which complicates the pay-off from the trade. See Nielson and Jeppesen (2003) for more details.

[22] The project has developed a co-operation between a group of utilities from Austria, Denmark, Germany, Holland, Italy, Norway, Sweden and UK.

5 Discussion and Conclusions

An integrated TREC market has a broad appeal as it helps to lower the cost of meeting environmental goals as well as offer flexibility and choice to its users. First of all it provides the technical flexibility - the TREC system integrates different renewable energy technologies, generating at different times and places. Second is market flexibility - the TREC is a tradable instrument that can serve the needs of an increasingly diverse and sophisticated market where consumers are facing more choices over the energy they buy, and who they buy it from. The development of an integrated TREC market will facilitate the integration of renewable energy into the deregulated, partially deregulated and the not yet deregulated markets. At the same time, it will economically compensate the RE technologies for the environmental benefits that they generate compared to the power production from the fossil fuels. Third the political flexibility - TRECs can help the implementation of a variety of policy instruments and allow economic integration at different scales. Trading systems could work at various geo-political levels.[23] In the U.S., an integrated TREC market will offer a highly efficient, flexible and cost effective way to comply with RPS (similar type of conclusion has been drawn by Andrews 2001 in Australian perspective).

In addition to the cost efficient way of producing renewable energy, an integrated TREC system provides economies of scale in regulation (see footnote 14). An integrated TREC market will dampen the price fluctuations caused by the intermittent supply of the renewable resources. A national or at least regional certificate trading system may also help to ease policy coordination problem (e.g. conflict between environmental disclosure and RPS) that the individual states are facing.[24]

[23]For example, across the member states like in U.S. or across the countries like in EU, country groups such as Scandinavia or the Mediterranean region, or within technical and trading zones such as the Nord Pool electricity market.

[24]Porter and Wiser (2000) argue that a regional environmental certificate trading program may resolve some of the policy conflicts. Potential conflicts can be whether the RECs are recognized by state environmental disclosure policies, how environmental disclosure treats out of state renewable energy supply and the

However the integrated TREC system does not necessarily benefit the local environment, which makes regulators stringent about the cross border transaction of environmental attributes. Future research should be directed to find ingenious ways to balance both the interests. The multi-level market structure suggested by Midttun and Koefoed (2003) may be one way to do this.[25] They argue that a multi-level market structure would simultaneously facilitate scale and scope advantages in large global and regional markets while protecting the local environment through locally tuned regulatory mechanisms. Grace and Wiser (2002) also propose "Super Market Geographic Eligibility" concept in transacting environmental attributes across market boundaries. According to this concept several markets (or states) are integrated into a super market which ensures environmental benefits inside the region covered by the super market territory. For example, one super market can be established for New York, New England and PJM (Pennsylvania, New Jersey and Maryland). If the RPS requirement is lower than the current share of renewable energy generation, the renewable energy generation may even decline in the absence of REC trading across states. This is likely to happen in Maine.

A number of other issues also need to be addressed in the organization of an integrated TREC market. These include the variability of the fluctuating renewable resources (e.g. seasonal variation in the supply of wind and solar power etc.), time lags in capacity development and the importance of setting the harmonized quotas and standard in the short run and long run. If these are not handled properly, integration steps might create high instability in the market. Hence, before switching to a fully integrated system, it may be wise to go through an experimental phase as was done in Europe (RECS 1999).

interaction with RPS compliance, differences in RPS eligibility and how it is examined etc.

[25] They suggest that renewable plants will be able to trade credits at local, regional and global levels.

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Table 1: Status of REC Trading in U.S.⋆

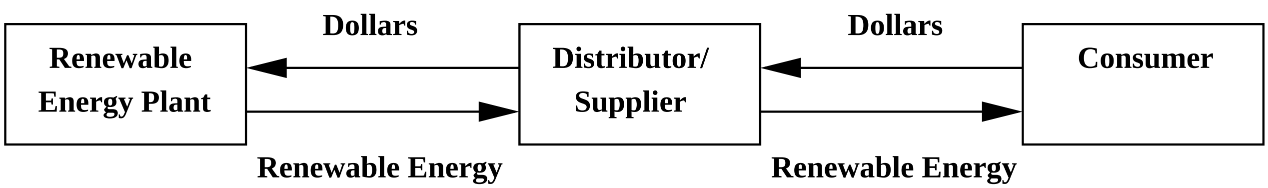
State	REC Trading Allowed	Program Designed and Allowed	Out-of-state Resources Allowed⋆⋆
Arizona	yes	no	no (for wind)
Connecticut	no	no⊕	yes
Maine	yes⊖	no	yes
Massachusetts	yes	no	yes
Nevada	yes	no⊘	no
New Jersey	yes	no	yes (with restrictions)
New Mexico	not addressed	no	no
Pennsylvania	not addressed	no	unspecified
Texas	yes	yes	yes (with restrictions)
Wisconsin	yes⊙	no	yes

⋆ - source: Wiser et. al. 2000.
⋆⋆ - resources include REC, tax rebates and other government subsidies.
⊕ - left for private markets.
⊖ - may be allowed but Public Utility Commission (PUC) decided not to implement.
⊘ - under development.
⊙ - only for renewable above RPS standard.

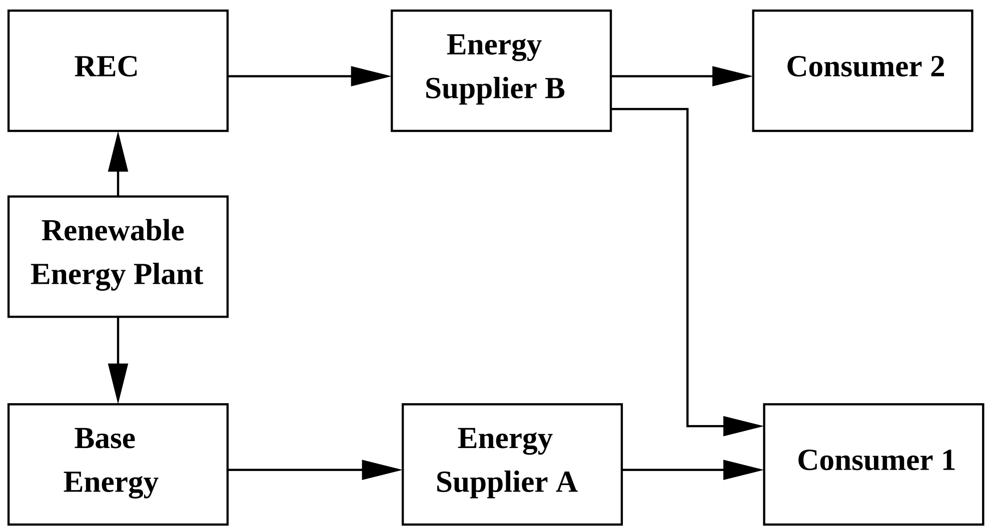
Table 2: Retail Products Offered by Renewable Energy Certificate Marketers* (as of March 2002)

Certificate Marketers	**Retail Product Name**	**Resources**	**Location of Resources**	**Price Premiums****
Bonneville Environmental Foundation	Green Tags	New wind, solar	Pacific Northwest	2.0c/kWh
Community Energy	New Wind Energy	New wind	Pennsylvania	2.5c/kWh
Los Angeles DWP	Green Power for Green LA Certificates	Wind, landfill methane	Wyoming, California	Minimum $5 contribution
Native Energy	Windbuilders	New wind	South Dakota	$120 annual membership
PG&E Corporation	Pure Wind Certificates	New wind	New York	4.0c/kWh
Renewable Choice Energy	American Wind	100% New wind	Texas	2.5c/kWh
Renewable Choice Energy	Eco Choice	90% Renewable, 10% new wind	California, Texas, other	1.8c/kWh
Sterling Planet	Sterling Planet Green Energy	Small hydro, geothermal, biomass	California	1.6c/kWh (20% premium)
Sun Power Electric Corp.	Regen	Biomass and solar	Rhode Island, Massachusetts	3.6c/kWh
Waverly Light and Power	Iowa Energy Tags	Wind	Iowa	2.0c/kWh

∗ - Source: Green Power Network May 2002.
∗∗ - Large users may be able to negotiate lower price premiums.



a) Bundled Transaction of Energy and Environmental Attributes



b) Unbundled Transaction of Energy and Environmental Attributes

Figure 1: Transaction of Energy and Environmental Attributes

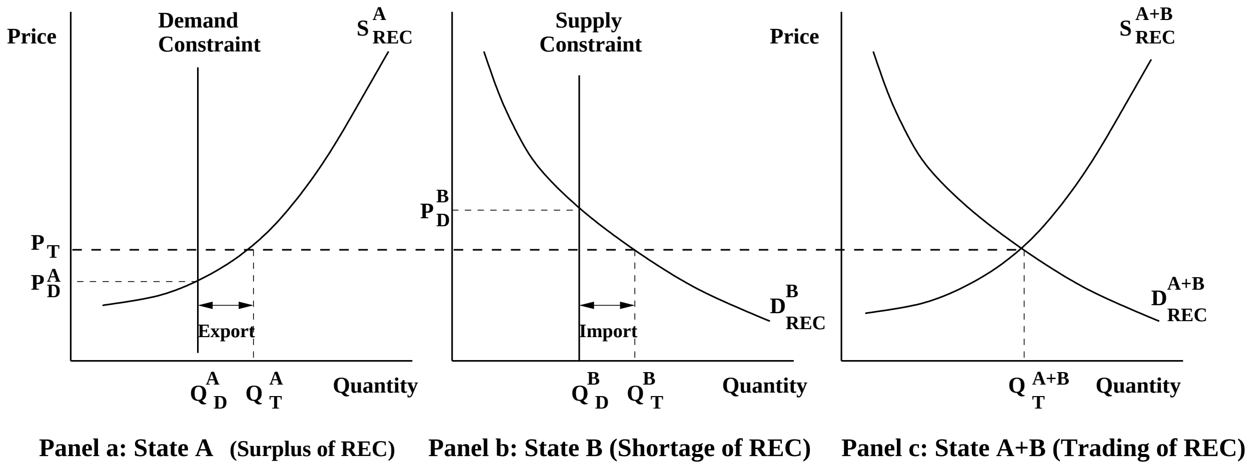


Figure 2: Trade of REC Across Different States

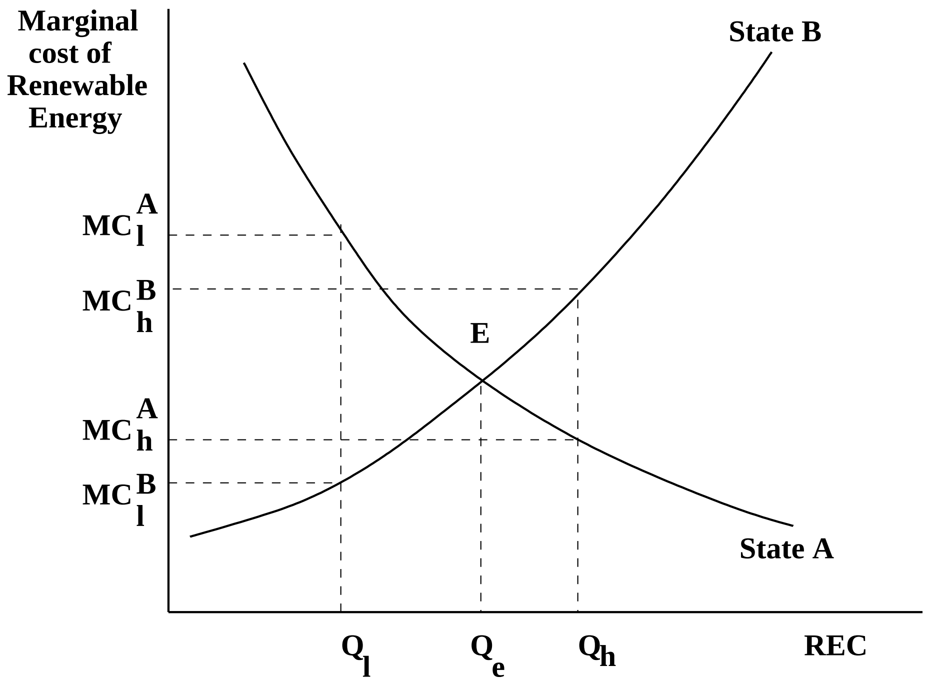


Figure 3: Efficiency with Integrated TREC Market